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ADAPTATIONS TO BEARING OF EGGS IN SOME MARINE BIVALVES

By T.A. Matveeva of the Zoological Institute of the USSR Academy of Sciences

The majority of marine bivalves cast mature sexual products into /39* the water, where fertilization and the development of embryos take place. In this method of reproduction, elimination of eggs and embryos is especially high and can be compensated for by an extremely high abundance of gametes. However, there are a number of specific adaptations in some species for the protection of developing embryos from the effects of harmful environmental factors that considerably improve their survival rate. Mollusks which show such adaptations are found among different families, often systematically very remote.

One of the simplest adaptations for the protection of embryos - larvipary - is observed in representatives of the family Ostreidae, and, in particular, in Ostrea edulis and O. lamellosa. The individuals of these species cast into the water only sperm; the mature eggs are retained by the females in the pallial cavity, where they are fertilized by sperm entering the shell with the flow of water. This method of external-internal fertilization (Beklemishev, 1964) undoubtedly increases the number of fertilized oyster eggs and considerably reduces losses. The embryos develop in the cavity for

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eight days and already mobile larvae emerge into the water (Ivanov and Strelkov, 1949; Raimboult, 1966; Golikov and Skarlato, 1967). In this case, the adaptation appears at an early stage of ontogenesis, and the death of eggs is reduced, which improves the effectiveness of fertilization.

In representatives of the family Astartidae, the females cast into the water large eggs, reaching 300 micrometers in size, rich in nutritive yolk and covered with two protective gelatinous membranes. In fertilized eggs, the gelatinous matter rapidly absorbs water, and the membranes swell considerably, the outer one becoming sticky and attaching the egg capsule to a solid substrate. During this entire period of development of the eggs, the membranes apparently play an important protective role, preserving the embryos from potentially fatal situations.

The gonads of the female contain relatively few large eggs: according to I. Oertzen (1972), with an average shell length of 24 mm, the female of Astarte borealis has an individual fecundity of 5500 eggs. Such Arctic species as Astarte borealis, A. elliptica and A. montagui are characterized by a rapid development of the embryo and an absence of pelagic larva (Thorson, 1935, 1936, 1946; Ockelmann, 1958; Saleuddin, 1964; Oertzen, 1972). It is known that in species which live in waters which are constantly exposed to a marked fluctuation in environmental factors, direct development has a substantial effect on the survival rate of embryos, reduces their mortality and increases the abundance of fry.

Bivalves include species which form clutches. In the family Veneridae, /40 such species include Turtonia minuta, a small form, up to 3 mm in size, which forms mass settlements on the littoral. This species also shows external-internal

Fig. 1. Clutch of Turtonia minuta with young mollusks ready for hatching.

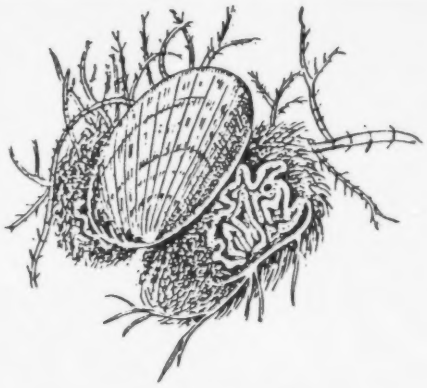

Fig. 2. Clutch of Musculus discors laid in a little house (after Rusanova, 1963).

Fig. 3. Clutch of Vilasina pillula, attached to a piece of alga; part of the stroma has been removed; the developing embryos can be seen inside.

fertilization; the developing large eggs, up to 100 micrometers in size, are enclosed in transparent gelatinous capsules which contain from 1 to 20 embryos (Fig. 1). The embryos undergo all stages of development in the clutch and emerge into the environment as fully formed mollusks.

In the family Mytilidae, representatives of the genus Musculus - /41 Musculus discors, M. laevigatus and M. senhousia have clutches. The shell size of these mollusks is relatively small - they range from 14 to 29 mm in size. The mollusks attach themselves by means of the bissus to algal thalli and form a peculiar house around the shell. The clutches are placed by females in the house in the form of white twisted cords, consisting of large eggs, up to 250 micrometers in size, glued together (Fig. 2). The first two species have direct development; in M. senhousia, apparently, veligers emerge from the clutches, continue their development in plankton, and having completed their metamorphosis, settle in algal thalli.

Still another Mytilidae species which makes clutches - Vilasina pillula- is found in the Sea of Japan at Posyet Bay and off the coast of the South Kurile Islands. This species has small shell, no more than 15 mm long and lives in algae, attaching itself by the bissus to thalli. We were able to establish that the females form clutches which consist of slimy round clumps of greenish-grey color, up to 12 mm in diameter; the outer membrane consists of interwoven bissus threads, held together by the mucous stroma, and is covered with a layer of fine detritus. This membrane gives the clutch a somewhat vague outline and considerably enlarges its size (Fig. 3). Developing veligers were found inside the transparent mucous stroma in July. In this case, the development of the embryos in this species can be assumed to be direct or with a brief plankton stage.

Some bivalve species bear eggs in a special outer sac attached to the shell. This adaptation was found (Drew, 1901) in a small (4 mm long) Nucula delphinodonta mollusk, living in the silty-sandy littoral of the Gulf of Maine. The sac consists of a leathery material, communicates with the pallial cavity and contains from 20 to 70 eggs. The eggs are large (average size 210 micrometers), opaque, cinnamon colored, and covered with a transparent membrane (Fig. 4.). The work cited gives all the stages of the embryonal development of N. delphinodonta, which lasts 3-4 weeks and ends with the emergence of the young mollusks into the environment.

Ovivivіparity is a further complication of the method of reproduction. Fi. Gilbert (1963) gives data on the reproduction of three species of the family Carditidae - Cardita ventricosa, C. barbarensis and C. bailui dwelling in coastal waters off Southern California. The mollusks are comparitively small (from 7.0 to 12.7 mm long); the females bear embryos under cover of the shell in the half-gill spaces (Fig. 5). The number of developing embryos in one female varies from 12 to 50. There is practically no definite reproductive season in Cardita ventricosa; according to W. Dall (1903), females with embryos in the gills are found in the population in almost all months of the year, except June.

Ovivivіparity is also observed in the Barents Sea Cardium elegantulum (Matveeva, 1953). The females of this species deposit developing eggs into two special brood pouches, formed by the folds of the ventral part of the pallial cavity. The development of the embryo is direct, without plankton larva, not only under cover of the shell, buteven within the brood pouch (Fig. 6).

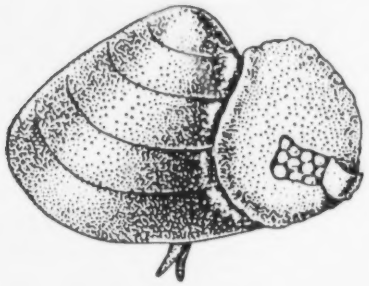

Fig. 4. View of the external brood pouch containing developing eggs in Nucula delphinodonta (after Drew, 1901).

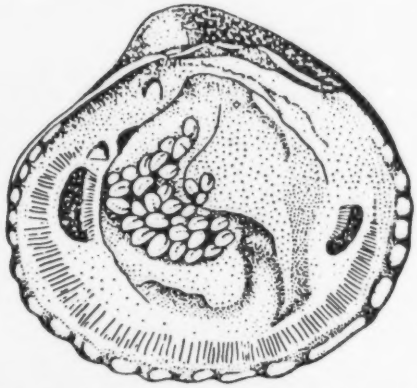

Fig. 5. Adult female of Cardita ventricosa with pallial cavity removed (left valve), with young embryos inside half-gills (after Gilbert, 1963).

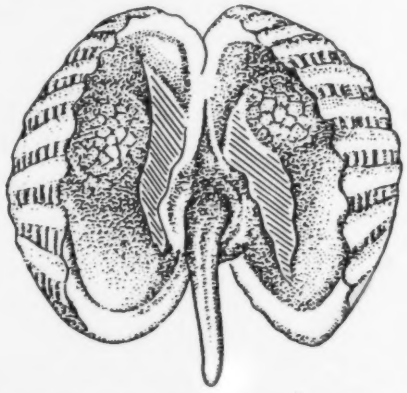

Fig. 6. Opened shell of adult Cardium elegantulum female with two brood pouches with young embryos.

In conclusion, adaptations to bearing of eggs (a unique form of concern for progeny) are found in bivalves at different phases of ontogenesis, beginning with the early egg phases and ending with subsequent embryonal phases. All the associated morphophysiological adaptations are directed at improving the forms and methods of reproduction to ensure protection of embryos from unfavorable factors.

The containment of vitellus in the egg is the most important /42 adaptation for the protection of progeny. According to G. Thorson (1950), large, vitellus-rich, few eggs determine in most cases the direct development of embryos, which considerably reduces the death of embryos and improves the reproductive capacity of mollusks.

We have noted that the morphophysiological adaptations directed at the preservation of the eggs and embryos are found in different families, particularly in species with small shell size or living in unstable, severe environment.

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